(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 973 355 A2

(12) EUROPÄISCHE PATENTANMELDUNG

(43) Veröffentlichungstag:
19.01.2000 Patentblatt 2000/03

(51) Int. Cl.^{7}: **H04R 1/22**, H04R 1/08, H04R 1/10, H04M 1/03

(21) Anmeldenummer: **99113735.7**

(22) Anmeldetag: **13.07.1999**

(84) Benannte Vertragsstaaten:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Benannte Erstreckungsstaaten:
AL LT LV MK RO SI

(30) Priorität: **15.07.1998 DE 19831771**

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(54) **Kunstoffkapselung für akustischen Wandler**

(57) Die Erfindung betrifft eine Kunststoffkapselung für einen akustischen Wandler bzw. einen gekapselten akustischen Wandler zum Einbau in ein Gehäuse insbesondere von Telekommunikationseinrichtungen sowie ein Verfahren zur Herstellung derselben.

Akustische Wandler sind häufig in Kunststoffkapselungen eingelagert, um sie vor akustischen Störeinflüssen zu schützen und um gewisse akustische Eigenschaften zu erzeugen oder zu verstärken. Darüber hinaus sind häufig die akustischen Eingänge der akustischen Wandler mit akustisch transparenten Reibungselementen, wie textilen Flächengebilden oder Membranen, versehen, die aufgrund ihrer akustischen Impedanz den Schalldruck, der die akustischen Eingänge der Wandler erreicht, gezielt beeinflußt.

Mit der Erfindung wird vorgeschlagen, diese akustisch transparenten Reibungselemente nicht an den akustischen Eingängen der Wandler anzubringen, sondern an den Schalldrucköffnungen der die akustischen Wandler umgebenden Kunststoffkapselung. Vorzugsweise werden die akustisch transparenten Reibungselemente beim Spritzgießen der Kunststoffkapselung unmittelbar mit in die Kunststoffkapseiung eingespritzt bzw. an diese angespritzt.

Die erfindungsgemäßen gekapselten akustischen Wandler sind vergleichsweise einfach und zuverlässig herstellbar und eignen sich für die Massenproduktion.

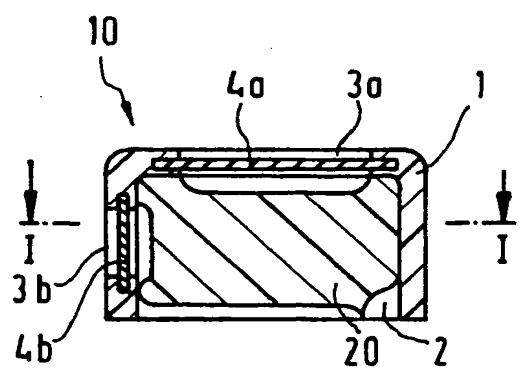

FIG.1A

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beschrieben, mit ihren Innenmaßen exakt auf die Außenmaße des akustischen Wandlers abgestimmt ist. Beim Einsetzen können daher die aufgeklebten Membrane an Kanten hängenbleiben oder sich reibungsbedingt wieder von dem akustischen Wandler lösen, was insbesondere bei Mikrophonen mit bidirektionalem Verhalten kritisch ist, da bei dieser Ausführungsart beim Einsetzen des Wandlers in die Kunststoffkapselung regelmäßig eine der Membranen an einer Innenwand der Kunststoffkapselung entlanggeschoben werden muß. Im Hinblick auf die Massenfertigung ist ein einfacheres und zuverlässigeres Herstellungsverfahren wünschenswert, das eine gleichbleibend hochwertige Qualität gewährleistet.

[0008] Aufgabe der vorliegenden Erfindung ist es daher, einen gekapselten akustischen Wandler mit akustisch transparentem Reibungselement zum Einbau in ein Gehäuse insbesondere einer Telekommunikationseinrichtung zu schaffen, welcher ohne viel Aufwand und in zuverlässiger Weise herstellbar ist.

[0009] Diese Aufgabe wird erfindungsgemäß durch die Merkmale der unabhängigen Ansprüche gelöst. Der Kern der Lösung ist darin zu sehen, daß das akustisch transparente Reibungselement nicht direkt auf dem akustischen Wandler sondern in bzw. an der Schalldrucköffnung der Kunststoffkapselung befestigt wird, indem es vorzugsweise beim Spritzen der Kunststoffkapselung angespritzt oder umspritzt wird.

[0010] Die Verbindung des akustisch transparenten Reibungselements, ein Flächentextil oder eine Membran, mit der erfindungsgemäßen Kunststoffkapselung kann entweder formschlüssig oder kraftschlüssig erfolgen. Als formschlüssige Verbindung bietet sich eine Schnappverbindung an, wobei das Schnappelement direkt an die Kunststoffkapselung, die üblicherweise spritzgegossen wird, angespritzt werden kann. In diesem Falle braucht das Reibungselement lediglich vor die Schalldrucköffnung plaziert und mittels Schnappverbindung eingeklemmt zu werden. Ein unbeabsichtiges Verschieben des Reibungselements beim Einsetzen des akustischen Wandlers ist somit ausgeschlossen, und dementsprechend ist auch das Anbringen des Reibungselements wesentlich unkritischer verglichen mit dem Aufkleben der Membran direkt auf dem akustischen Wandler.

[0011] Bevorzugt wird jedoch eine erfindungsgemäße Kunststoffkapselung, bei der das akustisch transparente Reibungselement bereits bei der Herstellung der Kunststoffkapselung durch "Umspritzen" bzw. "Anspritzen" fixiert wird. Auch dabei handelt es sich um eine formschlüssige Verbindung des Reibungselements mit der Kunststoffkapselung. Im Falle des "Anspritzens" wird der Formschluß dadurch erzeugt, daß das Kunststoffmaterial der Kunststoffkapselung in Poren und Rauhigkeiten zumindest von Teilbereichen der Textil- oder Membranoberfläche eingreift, während die gegenüberliegende Oberfläche frei von Kunststoff bleibt. Es hat sich herausgestellt, daß diese formschlüssige Verbindung völlig ausreichend ist. Eine noch stabilere Verbindung läßt sich jedoch erreichen, wenn das Reibungselement in seinem Randbereich kontinuierlich von einer Reibungselementoberfläche zu einer gegenüberliegenden Reibungselementoberfläche mit Kunststoffmaterial "umspritzt" wird.

[0012] Eine kraftschlüssige Verbindung des Reibungselements mit der Kunststoffkapselung ist zum Beispiel durch Adhäsionskräfte mittels Klebstoff möglich.

[0013] Weitere vorteilhafte Ausgestaltungen sind in den Unteransprüchen definiert und ergeben sich aus der nachfolgenden Beschreibung einer bevorzugten Ausführungsform.

[0014] In den Figuren bezeichnen:

Figur 1a eine Kunststoffkapselung für einen bidirektionalen akustischen Wandler im Querschnitt,

Figur 1b die Kunststoffkapselung nach Figur 1a in einem demgegenüber um 90° gedrehten Querschnitt,

Figur 2a eine Kunststoffkapselung für einen omnidirektionalen Wandler im Querschnitt, mit angespritztem Verschlußdeckel,

Figur 2b die Kunststoffkapselung aus Figur 2a mit geöffnetem, angespritzten Verschlußdeckel,

Figur 3 eine weitere Kunststoffkapselung gemäß der vorliegenden Erfindung mit einem angespritzten Reibungselement (4a) und einem umspritzten Reibungselement (4b),

Figur 4a eine perspektivische Ansicht einer Kunststoffkapselung aus dem Stand der Technik, in die ein bidirektionaler akustischer Wandler mit aufgeklebter Membran eingesetzt ist, und

Figur 4b einen selbstklebenden Membranzuschnitt nach dem Stand der Technik zur Verwendung in einer Vorrichtung nach Figur 4a.

[0015] In den Figuren sind gleiche Bauteile unterschiedlicher Ausführungsformen mit identischen Bezugsziffern bezeichnet.

[0016] In den Figuren 1 bis 3 sind erfindungsgemäße Kunststoffkapselungen 10 für akustische Wandler dargestellt, die so oder ähnlich zum Einbau in ein Gehäuse zum Beispiel einer Telekommunikationseinrichtung verwendet werden. Die Kunststoffkapselungen 10 definieren durch ihre Wandung 1 einen Aufnahmeraum 2 zur Aufnahme eines nur in Figur 1a exemplarisch dargestellten akustischen Wandlers 20. In den Wandungen 1 sind Schalldrucköffnungen 3 bzw. 3a und 3b vorgesehen, durch die der Schall aus der Umgebung zu dem bzw. den akustischen Eingängen des in dem Aufnah-

textilien aus synthetischem oder natürlichem Material.

[0025] Um die Stabilität der porösen Strukturen zu verbessern, wird das Reibungselement auf mindestens ein Trägermaterial wie ein Vlies, ein Gewebe, ein Gewirke, eine Lochplatte, ein Gitter oder nicht-gewebte Lagen aus unterschiedlichen Kunststoffmaterialien oder organischen Materialien aufgebracht. Als Trägermaterial eignet sich Polyester, Polyamid, Aramid oder ein Fluorpolymer, wobei nicht-gewebtes Polyester-Material mit dunkler Färbung bevorzugt wird. Ebenfalls besonders geeignet ist ein Trägermaterial aus Zellulose. Die Dicke eines solchen bevorzugten Trägermaterials liegt im Bereich von 40 bis 1000 µm, vorzugsweise 50 bis 200 µm.

[0026] Die akustisch transparenten Reibungselemente weisen üblicherweise sehr dünne Strukturen auf, um folgende Charakteristika zu erfüllen. Ihr akustischer Widerstandswert soll im Bereich von 0 bis 10000 Ohm liegen und der Schalldruckverlust zwischen 0 und 20 dB. Als mögliches Laminat für derartige Anwendungen eignet sich zum Beispiel das über die Anmelderin erhältliche GORE-TEX®-Laminat EV22209 oder EV22210.

[0027] Als Material für die Kunststoffkapselung eignen sich insbesondere vulkanisierbare Kunststoffe, wie zum Beispiel Silikone oder Naturkautschuk, und thermoplastische Kunststoffe, wie zum Beispiel Polypropylen, Polyethylen, Polycarbonate oder Polyamide sowie vorzugsweise thermoplastische Elastomere wie zum Beispiel Santoprene® (erhältlich über die Firma Montsanto/Italien) oder Hytrel® (erhältlich über die Firma DuPont). Alle diese Kunststoffe lassen sich im sogenannten Insert Moulding Spritzgußverfahren verwenden, welches den wesentlichen Vorteil bietet, daß das Spritzen der Kunststoffkapselung und ihre Verbindung mit den akustisch transparenten Reibungselementen in einem Arbeitsgang möglich ist. Insbesondere vereinen die thermoplastischen Elastomere die Eigenschaften, im Insert Moulding Spritzgußverfahren verarbeitet werden zu können und dabei ihre Elastomereigenschaften bewahren.

[0028] Die Herstellung der erfindungsgemäßen Kunststoffkapselung mit integriertem akustisch transparenten Reibungselement im Insert Moulding Spritzgußverfahren erfolgt folgendermaßen. Das Reibungselement wird zunächst in einem Spritzgußwerkzeug fixiert. Das kann dadurch bewirkt werden, daß das Reibungselement mittels einem Stempel so gegen eine Wandung des Spritzgußwerkzeugs gedrückt wird, daß nunmehr Randbereiche des Reibungselements in die Spritzgußform hineinragen. Dann erfolgt das Anspritzen des Kunststoffs mit dem Erfolg, daß die Oberfläche des Reibungselements mit der Oberfläche der Wandung der fertiggespritzten Kunststoffkapselung eben abschließt oder zumindest eine Seite des Reibungselements frei von Kunststoff bleibt. Wird dagegen das Reibungselement derart auf eine Erhöhung der Spritzgußformwandung gepreßt, daß sein Randbereich über diese Erhöhung seitlich übersteht, so ist es möglich, den Randbereich des Reibungselements zu umspritzen, so daß das Reibungselement wie in den Figuren 1 und 2 dargestellt, in der Wandung 1 fest eingefaßt ist. Bei einem Öffnungsdurchmesser von z.B. 5 mm genügt eine seitliche Einfassung des Reibungselementrandbereichs von etwa 0,5 mm. In besonderen Fällen kann es notwendig sein, das Reibungselement zwischen zwei Stempeln so zu fixieren, daß das Reibungselement beim Einspritzvorgang über die Stempel seitlich so hinausragt, daß der Randbereich des Reibungselements mit Spritzgußmaterial umspritzt werden kann. Die Herstellung erfolgt dann vorzugsweise gemäß dem in der EP 0 350 813 A2 von Sumitomo Electric Industries Limited beschriebenen Verfahren unter Verwendung zweier beweglicher Stempel.

[0029] Nach dem Entformen der Kunststoffkapselung aus dem Spritzgußwerkzeug kann der akustische Wandler problemlos und ohne Gefahr eines Ablösens der Membran in die Kunststoffkapselung eingesetzt werden.

[0030] Die Herstellung der Kunststoffkapselung mittels dem Insert Moulding Spritzgußverfahren bietet dabei den weiteren Vorteil, daß das Reibungselement absolut exakt an der gewünschten Stelle angeordnet ist, was bei den bekannten Verfahren problematisch ist.

[0031] Die erfindungsgemäße Kunststoffkapselung bietet außerdem den Vorteil, daß im Falle, daß alle Schalldrucköffnungen mit Reibungselementen verschlossen werden, die elektronischen Komponenten des akustischen Wandlers vor Umwelteinflüssen vollständig geschützt sind, insbesondere vor Staubpartikeln, Salzen und Flüssigkeiten. Dies gilt insbesondere, wenn die ePTFE-Membranen verwendet werden, denn diese sind zwar luftdurchlässig aber gleichzeitig wasserdicht und staubdicht. Der Wassereintrittsdruck solcher Reibungselemente sollte über 1 bar liegen.

<u>Verwendete Testverfahren</u>

[0032] Die Dicke der Membranen wurde mit einer Rachenlehre bestimmt, wobei ein Mittelwert von vier verschiedenen Stellen gebildet wurde.

[0033] Die Porosität ergibt sich nach der Formel

$$\text{Porosität} = 1 - \frac{\rho}{\rho_{spez}},$$

wobei ρ die scheinbare Dichte angibt, die sich als Quotient aus Masse zu Volumen einschließlich Lufteinschlüssen und Poren ergibt, und ρ_{spez} die spezifische Dichte des Materials angibt, wobei ρ_{spez} für PTFE bei etwa 2,2 g/m^3 liegt.

[0034] Die Luftdurchlässigkeit wurde nach dem ASTM Testverfahren D726-84 mit einem Gurley Dichtemeßgerät von W. & L.E. Gurley & Sons bestimmt.

[0035] Der Wassereintrittsdruck wurde anhand einer

wobei das Reibungselement porös ist und eine Porosität von 20 bis 98 % aufweist.

15. Vorrichtung nach einem der Ansprüche 1 bis 14, **wobei** das Reibungselement eine Dicke im Bereich von 0,5 bis 1000 µm aufweist.

16. Vorrichtung nach Anspruch 15, **wobei** das Reibungselement eine Dicke von 5 bis 100 µm aufweist.

17. Vorrichtung nach einem der Ansprüche 1 bis 16, **wobei** das Reibungselement als textiles Flächengebilde ausgebildet ist.

18. Vorrichtung nach einem der Ansprüche 1 bis 16, **wobei** das Reibungselement eine Membran ist.

19. Vorrichtung nach Anspruch 18, **wobei** die Membran luftdurchlässig und wasserdicht ist.

20. Vorrichtung nach Anspruch 18 oder 19, **wobei** für die Membrane ein Material verwendet wird, welches ausgewählt ist aus einer der Gruppe der folgenden gesinterten oder ungesinterten Materialien: Polypropylen, Polyester, Polyamid, Polyether, Polytetrafluorethylen (PTFE), Polysulfon, Ethylen-Tetrafluorethylen-Copolymer, fluoriertes Ethylenpropylen (FEP) und Tetrafluorethylen-/Perfluor(Propylvinyl)-Ether-Copolymer(PFA).

21. Vorrichtung nach Anspruch 20, **wobei** die Membrane aus expandiertem Polytetrafluorethylen (ePTFE) ist.

22. Vorrichtung nach einem der Ansprüche 1 bis 21, **wobei** das Reibungselement auf mindestens ein Trägermaterial laminiert ist.

23. Vorrichtung nach Anspruch 22, **wobei** das Trägermaterial ein Vlies, ein Gewebe, ein Gewirk, eine Lochplatte oder ein Gitter ist.

24. Vorrichtung nach Anspruch 22 oder 23, **wobei** das Trägermaterial ein Polyester, Polyamid, Aramid oder Fluorpolymer ist.

25. Vorrichtung nach einem der Ansprüche 22 bis 24, **wobei** das Trägermaterial nicht-gewebtes Polyester-Material ist.

26. Vorrichtung nach Anspruch 22 oder 23, **wobei** das Trägermaterial ein Zellulosematerial ist.

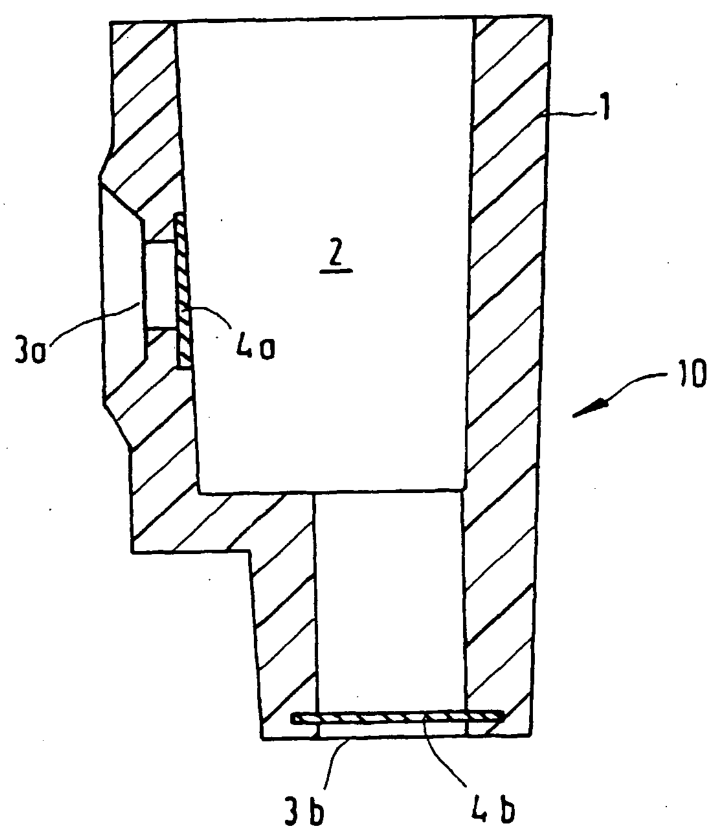
27. Verfahren zur Herstellung eines gekapselten akustischen Wandlers (20) nach einem der Ansprüche 2 bis 26 zum Einbau in ein Gehäuse insbesondere einer Telekommunikationseinrichtung mit folgenden Schritten:

- Vorbereiten einer Spritzgußform zum Kunststoffspritzen einer einen Aufnahmeraum zur Aufnahme eines akustischen Wandlers definierenden Kunststoffkapselung (10) mit einer Wandung (1), in der mindestens eine Schalldrucköffnung (3; 3a, 3b) vorgesehen ist,
- Einlegen eines akustisch transparenten Reibungselements (4; 4a, 4b) in die Spritzgußform im Bereich der vorgesehenen Schalldrucköffnung der Kunststoffkapselung,
- Einspritzen eines Kunststoffs in die Spritzgußform und aushärten des Kunststoffs, so daß das Reibungselement mit der gespritzten Kunststoffkapselung (10) formschlüssig verbunden ist und die Schalldrucköffnung verschließt,
- Einsetzen des akustischen Wandlers in die spritzgegossene Kunststoffkapselung (10), so daß ein akustischer Eingang des akustischen Wandlers in Schalldruckverbindung mit der durch das Reibungselement verschlossenen Schalldrucköffnung steht.

28. Verfahren nach Anspruch 27, **wobei** das Reibungselement (4; 4a, 4b) so in die Spritzgußform eingelegt wird, daß Randbereiche des Reibungselements beim Einspritzen des Kunststoffs mit dem Kunststoff umspritzt werden.

29. Verfahren nach Anspruch 27, **wobei** das Reibungselement (4; 4a, 4b) so in die Spritzgußform eingelegt wird, daß der Kunststoff zumindest in Teilbereichen des Reibungselements nur einseitig an das Reibungselement angespritzt wird.

FIG.3



(19) **European Patent Office** (11) **EP 0 973 355 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:

19.01.2000 Patent Gazette 2000/03

(21) Application number: **99113735.7**

(22) Date of application: **13.07.1999**

(51) Int. Cl.[7]: **H04R 1/22,** H04R 1/08, H04R 1/10, H04M 1/03

(84) Contracting states cited:

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

Extension states cited: **AL LT LV MK RO SI**

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(54) **Plastic encapsulation for acoustic converter**

(57) The invention relates to a plastic encapsulation for an acoustic converter and an encapsulated acoustic converter respectively for installation in a housing, in particular of telecommunications devices, as well as a method for the manufacture thereof.

Acoustic converters are frequently mounted in plastic encapsulations in order to protect them from acoustic interference influences and in order to create

or amplify certain acoustic properties. In addition to this, the acoustic inputs of the acoustic converters are frequently provided with acoustically transparent friction elements, such as textile surface structures or membranes, which because of their acoustic impedance influence in a specific manner the sound pressure which reaches the acoustic inputs of the converter.

It is proposed with the invention that these acoustically transparent friction elements be located not at the acoustic inputs of the converters, but at the sound pressure apertures of the plastic encapsulation surrounding the acoustic converters. Preferably, the acoustically transparent friction elements are injection-moulded directly into or onto the plastic encapsulation during the injection moulding of the plastic encapsulation itself.

The encapsulated acoustic converters according to the invention can be manufactured comparatively easily and reliably, and are suitable for mass production.

Description

[0001] The present invention relates to a plastic encapsulation for an acoustic converter and an encapsulated acoustic converter for installation in a housing, in particular of a telecommunications device, and a method for the manufacture of such an encapsulated acoustic converter.

[0002] Acoustic converters such as microphones, loudspeakers, and the like are frequently impressed or mounted in plastic mouldings in order then to be installed as units in housings of, for example, telecommunications devices. The plastic mouldings are necessary in order for special acoustic performance features of the acoustic converters, such as sound quality, bass frequency ranges or higher ranges, background noise, etc. to be optimised depending on the purpose of application. For this reason, the plastic mouldings are usually manufactured from a soft plastic or rubber, and define an accommodation space for the acoustic converter, whereby the accommodation space is dimensioned in such a way that the acoustic converter fits exactly into the plastic moulding. The plastic moulding therefore forms an encapsulation for the acoustic converter.

[0003] Such a plastic encapsulation has one or more sound pressure apertures, through which the sound can reach the acoustic input or inputs of the acoustic converter accommodated in the plastic encapsulation. The number of sound pressure apertures and the position of the acoustic converter in the plastic encapsulation have a substantial influence on the acoustic character of the device. With a microphone with "unidirectional" character, only one sound pressure aperture is provided for, and the acoustic input of the converter is relatively far removed from this sound pressure aperture, so that only directed sound reaches the converter. With a microphone with "omnidirectional" character, by contrast, the acoustic input of the converter is located close to the sound pressure aperture, so that sound from different directions can reach the acoustic input of the converter. Microphones with "bidirectional" character have

two inputs, which are preferably arranged at an angle of 90° to one another. Accordingly, background noise or undirected sound fractions can be eliminated, in that sound pressures which impinge in each case through the sound pressure apertures on opposing sides are conducted to a membrane which functions as an acoustic converter, so that the undirected sound pressure level of the background noises are offset against one another.

[0004] The acoustic performance features of the acoustic converters are not determined by the nature and structure of the plastic encapsulation alone, however. In addition to this, separate acoustically transparent friction elements in the form of textile surface structures or membranes, to which an acoustic impedance is assigned, are attached to the acoustic converter itself. In many cases these friction elements are porous and therefore air-permeable, in order to achieve the acoustic impedance. This means that the sound pressure does, as before, still reach the acoustic input of the acoustic converter due to the air permeability of the friction element, but characteristic friction or sound pressure losses occur, so that, by means of these acoustically transparent friction elements, specific acoustic effects can be achieved. The acoustically transparent friction element accordingly forms, in addition to the plastic or rubber encapsulation, an additional damping element, independent of the type and structure of the plastic encapsulation. The properties of a porous damping element depend in particular on the material thickness, porosity, and rated pore size. "Acoustically transparent" means in this connection that the sound energy is influenced by the friction element by 0 to 20 dB, depending on the characteristics required.

[0005] Hitherto, the acoustically transparent friction elements have been attached directly on the acoustic converter, such as a microphone, for example by adhesive bonding. The microphone prepared in this way is then inserted into the plastic encapsulation, in order then to be secured as a unit at a suitable location in a housing, for example of a mobile telephone.

[0006] In Figures 4a and 4b a device is shown according to the prior art, by way of the example of a bidirectional converter. The plastic encapsulation 10 has two

apertures 3a, 3b. A bidirectional converter is inserted in the plastic encapsulation 10 in such a way that their acoustic inputs come to be located behind the apertures 3a, 3b. The acoustic inputs are covered by a self-adherent membrane 4, which is attached to the converter before the converter before the converter is introduced into the plastic encapsulation 10. A corresponding section 4 with areas 4a and 4b for covering the acoustic inputs against the apertures 3a and 3b respectively is shown in Figure 4b by way of example. Such plastic encapsulations in the telecommunications sector usually have dimensions in the millimetric range and are, for example, 6 to 8 mm wide or deep and about 5 to 6 mm high. The apertures can be round or angular, for example with a diameter of 3.5 mm or an edge length of 2 mm x 2.8 mm.

[0007] The attachment of the acoustically transparent membrane to the acoustic converter is, however, problematic in several respects. On the one hand, the size of the acoustic converter, in particular in the telecommunications sector, as indicated heretofore, is of the order of only a few millimetres, with a further decreasing tendency. This makes the specific location of the membrane difficult, elaborate, and correspondingly cost-intensive. On the other hand, the acoustic converter prepared in this way must subsequently be inserted into the plastic encapsulation, which, as described heretofore, is matched with its inner dimensions exactly to the outer dimensions of the acoustic converter. When being inserted, therefore, the membrane which is adhesively attached may catch on edges or become detached again from the acoustic converter due to friction, which is critical in particular with microphones with bidirectional behaviour, since with this type of design, when the converter is inserted into the plastic encapsulation, one of the membranes must regularly be pushed along an inner wall of the plastic encapsulation. With regard to mass production, a more simple and more reliable manufacturing method would be desirable, which would guarantee a consistently high quality.

[0008] The object of the present invention is therefore to provide an encapsulated acoustic converter with acoustically transparent friction element for installation in a housing, in particular of a telecommunications device, which can

be manufactured without great effort and in a reliable manner.

[0009] This object is achieved according to the invention by the features of the independent claims. The core of the solution is to be seen in that the acoustically transparent friction element is secured not directly on the acoustic converter but in or at the sound pressure aperture of the plastic encapsulation, in that it is injection-moulded on or around this preferably during the injection moulding of the plastic encapsulation.

[0010] The connection of the acoustically transparent friction element, a surface textile or a membrane, to the plastic encapsulation according to the invention can be effected either as a positive or non-positive fit. As a positive-fit connection, a snap connection is suitable, whereby the snap element can be injection moulded directly onto the plastic encapsulation, which is usually injection moulded. In this case, the friction element needs only be placed in front of the sound pressure aperture and clamped in place by means of snap connections. Unintentional displacement of the friction element when the acoustic converter is inserted is therefore excluded, and accordingly the attachment of the friction element is considerably less critical in comparison with the adhesive bonding of the membrane directly on the acoustic converter.

[0011] Preferred, however, is a plastic encapsulation according to the invention in which the acoustically transparent friction element is already fixed by "encapsulation moulding" or "gating" as early as during the manufacture of the plastic encapsulation. In this case too, a positive-fit connection of the friction element to the plastic encapsulation is involved. In the case of "gating", the positive fit is created by the plastic material of the plastic encapsulation engaging in pores and roughnesses at least of part areas of the textile or membrane surface, while the surface located opposite remains free of plastic. It has transpired that this positive-fit connection is entirely adequate. An even more stable connection can be achieved, however, if the friction element is continually "encapsulation moulded" with plastic material in its peripheral area from one friction element surface to an opposite friction element surface.

[0012] A non-positive connection of the friction element with the plastic

encapsulation is possible, for example, by means of adhesion forces provided by adhesive bonding.

[0013] Further advantageous configurations are defined in the sub-claims and derive from the following description of a preferred embodiment.

[0014] The Figures show the following:

Figure 1a: A plastic encapsulation for a bidirectional acoustic converter, in a cross-section,

Figure 1b: The plastic encapsulation according to Figure 1a, in a cross-section rotated through 90° in comparison with this,

Figure 2a: A plastic encapsulation for an omnidirectional converter in a cross-section, with a closure lid injection-moulded onto it,

Figure 2b:. The plastic encapsulation according to Figure 2a, with open closure cover attached to it by injection moulding,

Figure 3: A further plastic encapsulation according to the present invention, with a friction element (4a) injection moulded onto it and a friction element (4b) encapsulation-moulded around it,

Figure 4a: A perspective view of a plastic encapsulation from the prior art, into which a bidirectional acoustic converter with a membrane adhesively bonded to it has been inserted, and

Figure 4b: A self-adhering membrane section according to the prior art, for use in a device according to Figure 4a.

[0015] In the Figures, the same components from different embodiments are designated with identical reference numbers.

[0016] Shown in Figures 1 to 3 are plastic encapsulations 10 according to the invention for acoustic converters, which are used in this manner or similar for installation in a housing, for example of a telecommunications device. The plastic encapsulations 10 define by their walls 1 an accommodation area 2 for the accommodation of an acoustic converter 20, shown in Figure 1a only by way of example. Provided in the walls 1 are sound pressure apertures 3 or 3a and 3b respectively, through which the sound from the surrounding area can pass to the acoustic input or inputs of the acoustic converter 20 provided in the accommodation area 2. In the case of an omnidirectional or unidirectional converter, one single sound pressure aperture 3 is sufficient, while in the case of a bidirectional converter two sound pressure apertures 3a and 3b are provided for, which for the reasons indicated heretofore and as shown in Figure 1a, are aligned preferably at right angles to one another. The sound pressure apertures are in each case closed by an acoustically transparent friction element; this is preferably a textile surface structure or a membrane, which does indeed allow the sound pressure to pass through, but at the same time influences it because of the acoustic impedance inherent to the friction element. There are embodiments conceivable, however, in which an aperture can be formed without a friction element. With other embodiments, the apertures can be closed off with friction elements which are different in terms of the acoustic impedance (e.g. 100 and 500 Ohm) or the same.

[0017] The acoustically transparent friction elements 4 and 4a, 4b respectively in the embodiments represented in Figures 1 and 2 are enclosed by the wall 3 in such a way that the wall material extends continually from the upper face of the friction element onto the corresponding rear face of the friction element located opposite. This is achieved according to the method in that the friction element is introduced into a mould for the injection moulding of the plastic encapsulation 10 before the injection moulding process begins. The friction element 4 is then encapsulation-moulded during the injection moulding process in such a way that it is securely connected in positive fit to the wall 1.

[0018] While Figure 1 shows a plastic encapsulation 10 for a bidirectional

converter 20 in two cross-sections located perpendicular to one another, Figure 2 shows a plastic encapsulation 10 for an omnidirectional converter with only one acoustically transparent friction element 4, likewise in cross-section. Injection-moulded onto the plastic encapsulation 10 according to the embodiment represented in Figure 2, a closure cover 5 is injection-moulded over a film hinge 6, so that the plastic encapsulation can be closed without any problems, in that the closure cover 5 engages behind the nose 7.

[0019] Figure 3 shows a further embodiment example of a plastic encapsulation 10 according to the present invention. While the acoustically transparent friction element 4b, in accordance with the embodiments described heretofore in accordance with Figure 1 and Figure 2 is "encapsulation moulded" with plastic material of the wall 1, the friction element 4a is only "moulded on". In the case of moulding on, too, this is a positive-fit connection between the friction element 4a and the wall 1, because the plastic material penetrates into the pores and surface roughnesses of the friction element 4a during the injection moulding process and forms an anchoring.

[0020] The acoustically transparent friction element can, however, as an alternative be fixed in the wall by way of snap closure, similar to the snap closure represented in Figure 2 in connection with the closure cover 5, or also be adhesively bonded directly onto the surface of the wall 1.

[0021] Depending on the requirement, it may also be appropriate for only one of several apertures to be closed with an acoustically transparent friction element.

[0022] Particularly well-suited as acoustically transparent friction material is any porous material which does indeed allow the sound pressure through, but influences it in a characteristic manner because of its acoustic impedance. Accordingly, porous films or membranes are particularly well-suited, made of sintered or unsintered synthetic polymers such as, for example, polypropylene, polyester, polyamide, polyether, polytetrafluoroethylene (PTFE), polysulphone, ethylene-tetrafluorethylene copolymer, fluorinated ethylene propylene (FEP), and tetrafluorethylene-/perfluor(propylvinyl)-ether-copolymer (PFA). The fluoropolymers referred to are preferred because of their processing properties,

temperature resistance, and chemical inertness. Particularly preferred are porous membranes made of polytetrafluoroethylene. For aesthetic reasons, these may contain dark pigments or colouring agents.

[0023] Porous polytetrafluoroethylene films which are suitable for use with the invention can be manufactured in accordance with known methods, such as by extending or drawing processes, by paper manufacturing processes, by processes in which filler material is deposited in the PTFE resin and then removed in order to leave a porous structure behind, or by powder sintering processes. Preferably, as a porous PTFE a porous expanded PTFE film is used with a structure consisting of interconnected nodes and fibrils, such as described in US Patents Nos. 3,953,566 and 4,187,390, which describe the preferred material and the preferred methods for the manufacture of the film. The nodes and febrils define an internal structure with a three-dimensional network of interlinked passages and permeations which extend perpendicular from one surface to another and laterally from one edge to another through the membrane. The porous PTFE film should have a thickness in the range from 0.5 to 1000 µm, preferably in the range from 5 to 100 µm, a porosity in the range from 20 to 98%, preferably in the range from 80 to 90%, an air permeability from 0.05 to 30 Gurley seconds, preferably 0.5 to 30 Gurley seconds, and a rated pore size in the range from 0.05 to 50 µm, preferably in the range from 3 to 20 µm.

[0024] Instead of a membrane, however, a textile surface structure with suitable properties can also be used. Suitable as a textile surface structure are fabrics, knits, non-woven fleeces, and microfibre textiles made of synthetic or natural material.

[0025] In order to improve the stability of the porous structures, the friction element is located on at least one carrier element, such as a non-woven fleece, a fabric, a knit, a perforated plate, a lattice, or non-woven layers of different plastic materials or organic materials. As a carrier material, polyester, polyamide, aramide, or a fluoropolymer are suitable, whereby non-woven polyester material with dark coloration is preferred. Likewise particularly suitable is a carrier material made of cellulose. The thickness of such a preferred carrier material is in the

range from 40 to 1000 µm, preferably from 50 to 200 µm.

[0026] The acoustically transparent friction elements usually have very thin structures, in order to fulfil the following characteristics. Their acoustic resistance value should be in the range from 0 to 10000 Ohm and the sound pressure loss between 0 and 20 dB. Suitable as a possible laminate for such applications are, for example, the GORE-TEX® laminates EV22209 or EV22210, available from the Applicants

[0027] Suitable as a material for the plastic encapsulation are, in particular, vulcanisable plastics, such as silicones or natural rubber, and thermoplastic materials, such as polypropylene, polyethylene, polycarbonates, or polyamides, as well as, preferably, thermoplastic elastomers such as Santoprene® (available from Montsanto/Italy) or Hytrel® (available from DuPont). All these plastics can be used in what is known as the insert moulding injection moulding process, which offers the substantial advantage that the injection moulding of the plastic encapsulation and its connection to the acoustically transparent friction elements can be carried out in one work cycle. In particular, the thermoplastic elastomers combine the properties of being able to be processed in the insert moulding injection moulding process, and in this situation preserve their elastomer properties.

[0028] The manufacture of the plastic encapsulation according to the invention, with integrated acoustically transparent friction element in the insert moulding injection moulding process is carried out as follows. The friction element is first fixed in an injection mould. This can be done by the friction element being pressed by means of a punch against a wall of the injection mould in such a way that peripheral areas of the friction element now project into the injection mould. The attachment moulding of the plastic then takes place, with the result that the surface of the friction element closes flat with the surface of the wall of the finish-moulded plastic encapsulation, or at least one face of the friction element remains free of plastic. If, by contrast, the friction element is pressed in such a manner onto an elevation in the injection mould wall in such a way that its peripheral area projects laterally beyond this elevation, it is then possible for the

peripheral area of the friction element to be encapsulated moulded in such a way that the friction element is secured in the wall 1, as represented in Figures 1 and 2. With an aperture diameter of, for example, 5 mm, a lateral inclusion of the friction element peripheral area of some 0.5 mm is sufficient. In special cases, it may be necessary for the friction element to be fixed between two punches in such a way that the friction element projects laterally beyond the punch during the injection moulding process in such a way that the peripheral area of the friction element can be encapsulated by injection moulding material. Manufacture is then carried out preferably in accordance with the method described in EP 0 350 813 A2 from Sumitomo Electric Industries Limited, making use of two movable punches.

[0029] After the removal of the plastic encapsulation from the injection mould, the acoustic converter can be inserted into the plastic encapsulation without any problem and without any risk of the membrane becoming detached.

[0030] The manufacture of the plastic encapsulation by means of the insert moulding process offers the further advantage in this situation that the friction element is arranged exactly at the desired position, which is problematic with known methods.

[0031] The plastic encapsulation according to the invention also offers the advantage that in the event of all the sound pressure apertures being closed with friction elements, the electronic components of the acoustic converter are completely protected against environmental influences, and in particular against dust particles, salts, and fluids. This applies in particular if ePTFE membranes are being used, since these are indeed air-permeable, but at the same time are water-tight and dustproof. The water ingress pressure of such friction elements should be above 1 bar.

Test methods used

[0032] The thickness of the membrane was determined by means of a snap gauge, whereby a mean value was formed from four different locations.

[0033] The porosity is derived from the formula:

$$\text{Porosity} = 1 - \frac{\rho}{\rho_{spec}}$$

where ρ is the apparent density, derived as a quotient of the mass to the volume, including air enclosures and pores, and ρ_{spec} is the specific density of the material, whereby ρ_{spec} for PTFE is about 2.2 g/m3.

[0034] The air permeability was determined in accordance with the ASTM test method D726-84 with a Gurley density measuring device from W. & L.E. Gurley & Sons.

[0035] The water ingress pressure was measured on the basis of an ePTFE membrane, which was tensioned between two test plates, by means of which a water pressure can be exerted onto the membrane over the lower plate. A pH paper was arranged between the upper plate and the membrane in order to demonstrate the ingress of water through the membrane. The pressure was increased in small steps, and after each increase a period of 10 seconds was allowed to elapse before the pH paper was examined. The water ingress pressure is the water pressure at which the pH paper changes colour because of water penetration, whereby the test results are taken from the middle of the membrane in order to avoid influences from damage in the peripheral area.

Claims

1. Plastic encapsulation (10) for an acoustic converter for installation in a housing, in particular of a telecommunications device, whereby

- The plastic encapsulation has a wall (1), which defines an accommodation space (2) for an acoustic converter,
- The wall (1) has at least one sound pressure aperture (3; 3a, 3b), through which a sound pressure can reach an acoustic input of an acoustic

converter accommodated in the plastic encapsulation,

whereby at least one of the sound pressure apertures (3; 3a, 3b) is closed by an acoustically transparent friction element (4; 4a, 4b), in order to influence the acoustic properties of the plastic encapsulation.

2. Encapsulated acoustic converter (20) for installation in a housing, in particular of a telecommunications device, whereby

- A plastic encapsulation (10) with a wall (1) is provided, which defines an accommodation area (2) in which the acoustic converter is accommodated,
- the wall has at least one sound pressure aperture (3; 3a, 3b), through which a sound pressure can reach an acoustic input of the acoustic converter accommodated in the plastic encapsulation, and
- an acoustically transparent friction element (4; 4am 4b) is provided for, in order to influence the acoustic properties of the encapsulated acoustic converter,

whereby the plastic encapsulation (10) is provided with and closed by the acoustically transparent friction element at at least one of the sound pressure apertures (3; 3a, 3b).

3. Device according to one of Claims 1 or 2, whereby the plastic encapsulation (10) has two sound pressure apertures (3a, 3b).

4. Device according to any one of Claims 1 to 3, whereby the surface normals of the sound pressure apertures (3a, 3b) are arranged at right angles to one another.

5. Device according to any one of Claims 1 to 4, whereby the friction element

(4; 4a, 4b) is connected by positive fit to the plastic encapsulation (10).

6. Device according to Claim 5, whereby the friction element is clamped in the plastic material of the plastic encapsulation by means of a snap connection.

7. Device according to Claim 5, whereby at least part areas of a surface of the friction element (4a, Fig. 3) are connected by positive fit to the plastic encapsulation, in that the plastic material of the plastic encapsulation engages in the pores and roughnesses of the friction element surface, and whereby an opposite surface of the friction element is free of plastic.

8. Device according to Claim 5, whereby the plastic material of the plastic encapsulation (10), in at least one peripheral area of the friction element, extends continuously from one friction element surface to a friction element surface located opposite.

9. Device according to any one of Claims 1 to 4, whereby the friction element is connected by non-positive fit to the plastic encapsulation (10).

10. Device according to any one of Claims 1 to 9, whereby the plastic encapsulation (10) is an integral component made of vulcanisable plastic.

11. Device according to Claim 10, whereby a material is used for the plastic encapsulation (10) which is selected from silicone or natural (unvulcanised) rubber.

12. Device according to any one of Claims 1 to 9, whereby the plastic encapsulation (10) is an integral component made of thermoplastic material.

13. Device according to any one of Claims 1 to 9, whereby the plastic encapsulation (10) is an integral component made of thermoplastic elastomer.

14. Device according to any one of Claims 1 to 13, whereby the friction element is porous and has a porosity of 20 to 98 %.

15. Device according to any one of Claims 1 to 14, whereby the friction element has a thickness in the range from 0.5 to 1000 μm.

16. Device according to Claim 15, whereby the friction element has a thickness from 5 to 100 μm.

17. Device according to any one of Claims 1 to 16, whereby the friction element is designed as a textile surface structure.

18. Device according to any one of Claims 1 to 16, whereby the friction element is a membrane.

19. Device according to Claim 18, whereby the membrane is air-permeable and watertight.

20. Device according to Claim 18 or 19, whereby a material is used for the membrane which is selected from the group of the following sintered or unsintered materials: Polypropylene, polyester, polyamide, polyether, polytetrafluoroethylene (PTFE), polysulphone, ethylene-tetrafluorethylene copolymer, fluorinated ethylene propylene (FEP), and tetrafluorethylene-/perfluor(propylvinyl)-ether-copolymer (PFA).

21. Device according to Claim 20, whereby the membrane is made of expanded polytetrafluoroethylene (ePTFE).

22. Device according to any one of Claims 1 to 21, whereby the friction element is laminated onto at least one carrier material.

23. Device according to Claim 22, whereby the carrier material is a non-woven fleece, a fabric, a knit, a perforated plate, or a lattice.

24. Device according to Claim 22 or 23, whereby the carrier material is made of polyester, polyamide, aramide, or fluoropolymer.

25. Device according to any one of Claims 22 to 24, whereby the carrier material is non-woven polyester material.

26. Device according to Claim 22 or 23, whereby the carrier material is a cellulose material.

27. Method for the manufacture of an encapsulated acoustic converter (20) in accordance with one of Claims 2 to 26, for installation in a housing, in particular of a telecommunications device with the following steps:

- Preparation of an injection mould for plastic injection moulding of a plastic encapsulation (10) defining an accommodation space for accommodating an acoustic converter, with a wall (1) in which at least one sound pressure aperture (3; 3a, 3b) is provided,
- Insertion of an acoustically transparent friction element (4; 4a, 4b) into the injection moulding in the area of the sound pressure aperture of the plastic encapsulation,
- Injection of a plastic into the injection moulding and hardening of the plastic, so that the friction element is connected by positive fit to the injected plastic encapsulation (10), and closes the sound pressure aperture,

- Insertion of the acoustic converter into the injection-moulded plastic encapsulation (10), so that an acoustic input of the acoustic converter is in sound pressure connection with the sound pressure aperture closed by the friction element.

28. Method according to Claim 27, whereby the friction element (4; 4a, 4b) is inserted into the injection moulding in such a way that peripheral areas of the friction element are encapsulated by the plastic when it is injected.

29. Method according to Claim 27, whereby the friction element (4; 4a, 4b) is inserted into the injection moulding in such a way that, at least in part areas of the friction element, the plastic is injected into the friction element on only one side.